

Advanced in Operating Systems Design (CS60038)

Assignment - 1 Part - A

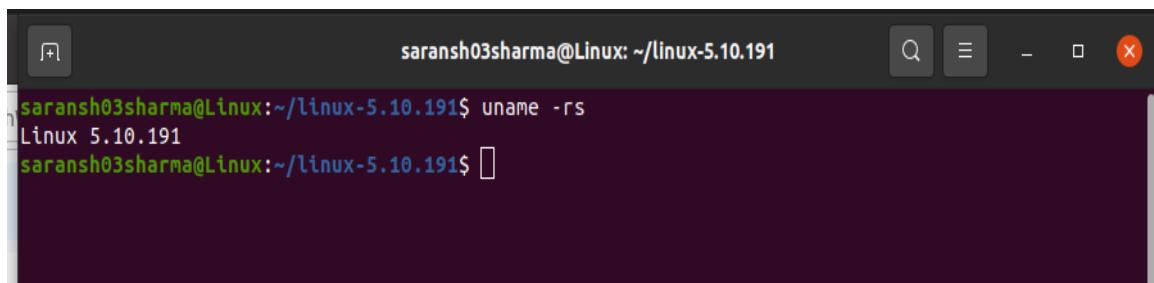
Pranav Mehrotra 20CS10085

Saransh Sharma 20CS30065

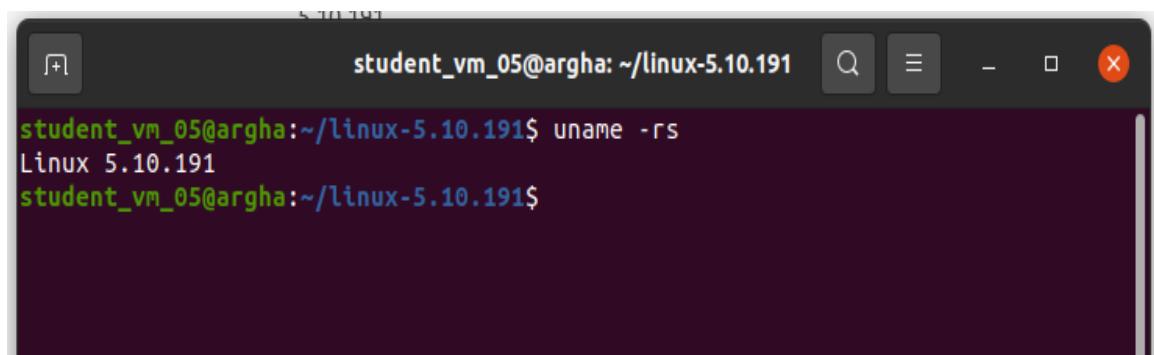
Task: Apply the following changes while installing kernel version 5.10.191

1. Remove NUMA memory allocation, scheduler, and emulation
2. Remove Kyber I/O Scheduler
3. Include multipath TCP (MPTCP)

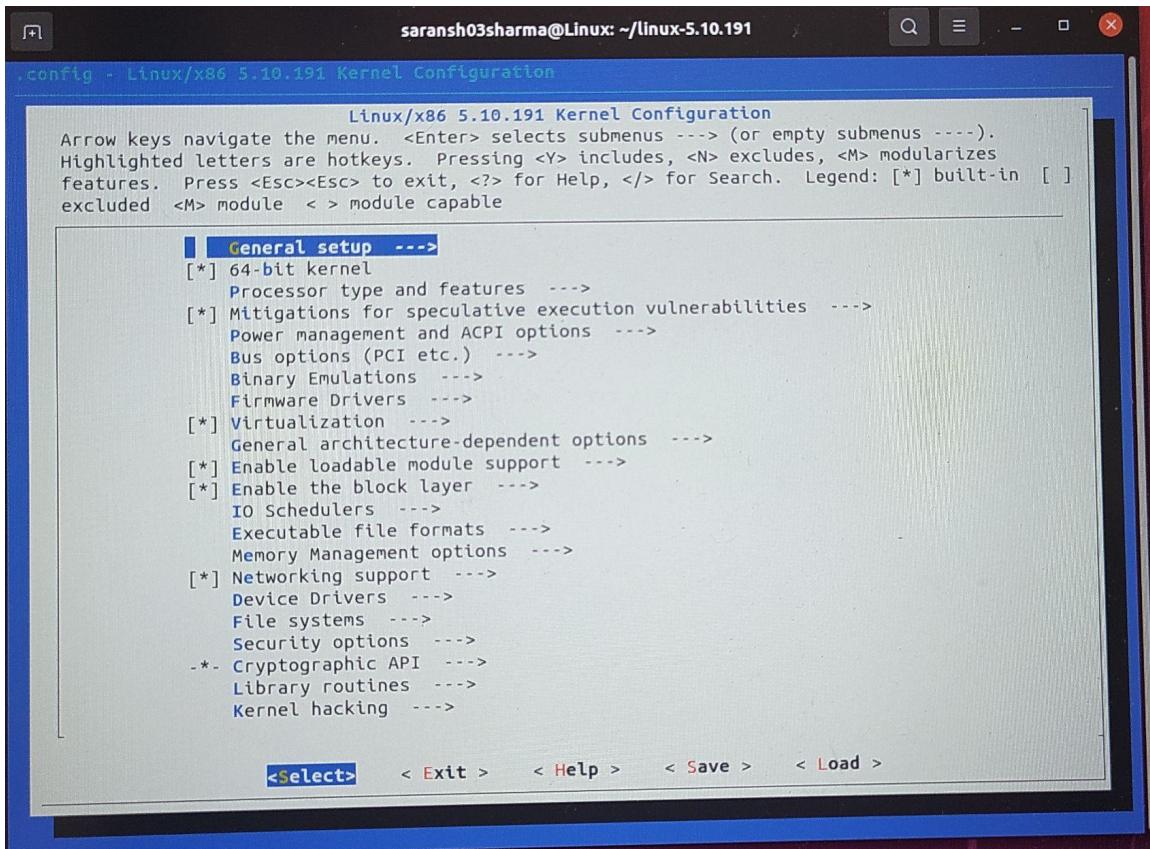
Note: For comparing differences in behaviour, an unmodified version of kernel 5.10.191 is installed in the VM with username student_vm_05 while saransh03sharma contains the kernel after applying the above changes.



```
saransh03sharma@Linux:~/linux-5.10.191$ uname -rs
Linux 5.10.191
saransh03sharma@Linux:~/linux-5.10.191$ 
```

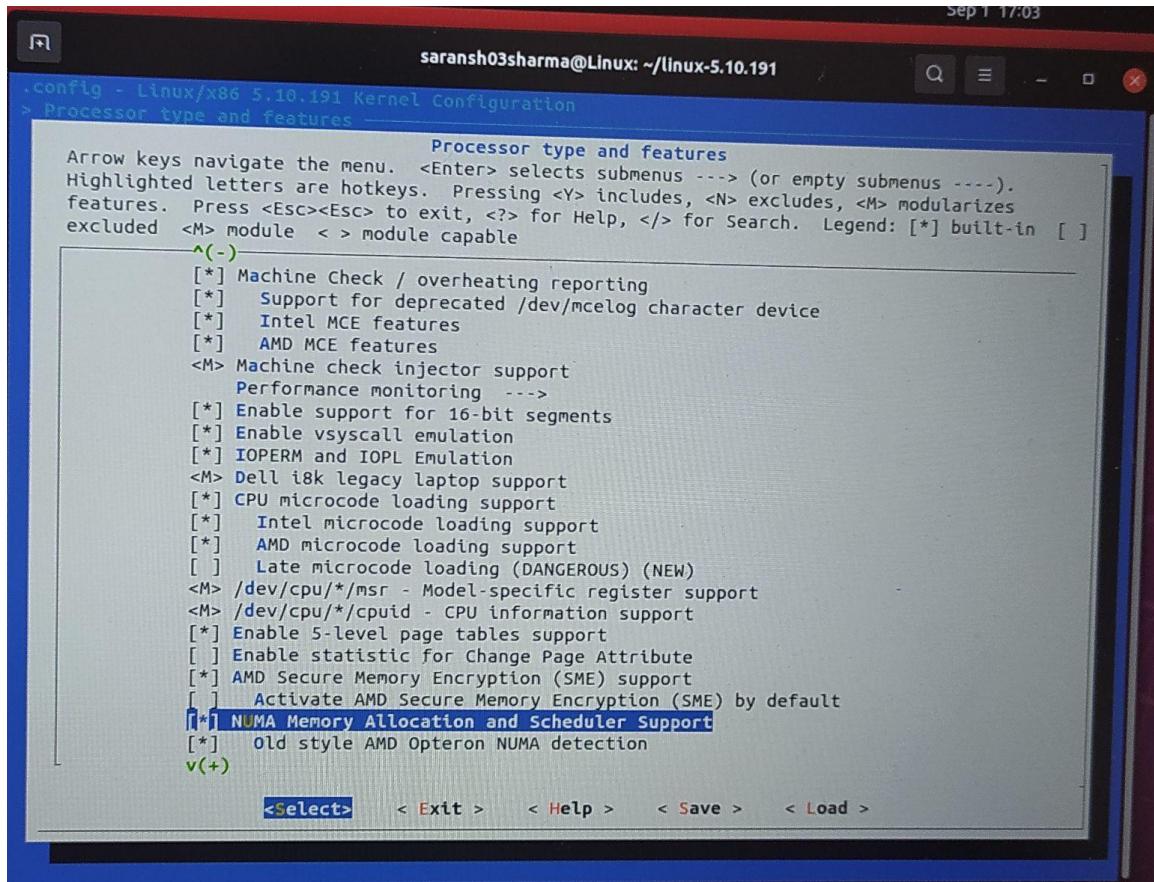


```
student_vm_05@argha:~/linux-5.10.191$ uname -rs
Linux 5.10.191
student_vm_05@argha:~/linux-5.10.191$ 
```



NUMA memory allocation, scheduler, and emulation

Before removing NUMA:



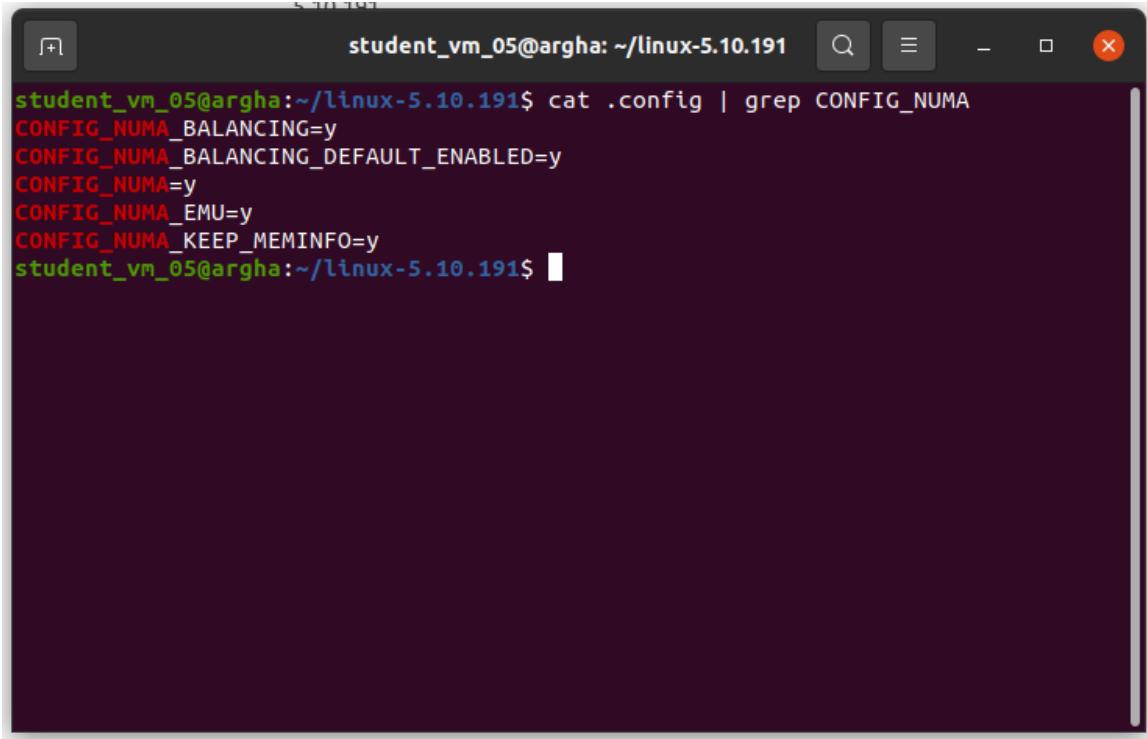
The screenshot shows a terminal window titled "saransh03sharma@Linux: ~/linux-5.10.191" with the command ".config - Linux/x86 5.10.191 Kernel Configuration" running. The window title bar also displays "Processor type and features". The terminal content is a menu for processor type and features, with the following text visible:

```
Processor type and features
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenus ----).
Highlighted letters are hotkeys. Pressing <Y> includes, <N> excludes, <M> modularizes
features. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] built-in [ ]
excluded <M> module < > module capable
^(-)
[*] Machine Check / overheating reporting
[*] Support for deprecated /dev/mcelog character device
[*] Intel MCE features
[*] AMD MCE features
<M> Machine check injector support
    Performance monitoring --->
[*] Enable support for 16-bit segments
[*] Enable vsyscall emulation
[*] IOPERM and IOPL Emulation
<M> Dell i8k legacy laptop support
[*] CPU microcode loading support
[*] Intel microcode loading support
[*] AMD microcode loading support
[ ] Late microcode loading (DANGEROUS) (NEW)
<M> /dev/cpu/*/msr - Model-specific register support
<M> /dev/cpu/*/cpuid - CPU information support
[*] Enable 5-level page tables support
[ ] Enable statistic for Change Page Attribute
[*] AMD Secure Memory Encryption (SME) support
[ ] Activate AMD Secure Memory Encryption (SME) by default
[*] NUMA Memory Allocation and Scheduler Support
[*] Old style AMD Opteron NUMA detection
v(+)

<Select> < Exit > < Help > < Save > < Load >
```

- In the .config file

The below picture shows that the CONFIG_NUMA field is set to yes.



```
student_vm_05@argha:~/linux-5.10.191$ cat .config | grep CONFIG_NUMA
CONFIG_NUMA_BALANCING=y
CONFIG_NUMA_BALANCING_DEFAULT_ENABLED=y
CONFIG_NUMA=y
CONFIG_NUMA_EMU=y
CONFIG_NUMA_KEEP_MEMINFO=y
student_vm_05@argha:~/linux-5.10.191$
```

- Verification of NUMA

The below picture shows the list of nodes found using numactl --hardware command.



```
student_vm_05@argha:~/linux-5.10.191$ numactl --hardware
available: 1 nodes (0)
node 0 cpus: 0 1 2 3
node 0 size: 3912 MB
node 0 free: 156 MB
node distances:
node 0
 0: 10
student_vm_05@argha:~/linux-5.10.191$
```

After Removing NUMA:

The screenshot shows a terminal window titled ".config - Linux/x86 5.10.191 Kernel Configuration". The user is in the "Processor type and features" submenu. The menu displays various processor-related options, including Intel and AMD MCE features, machine check injector support, and various CPU microcode loading options. A specific option, "NUMA Memory Allocation and Scheduler Support", is highlighted in blue. At the bottom of the menu, there are navigation keys: <Select>, < Exit >, < Help >, < Save >, and < Load >.

Processor type and features → NUMA Memory Allocation and Scheduler Support

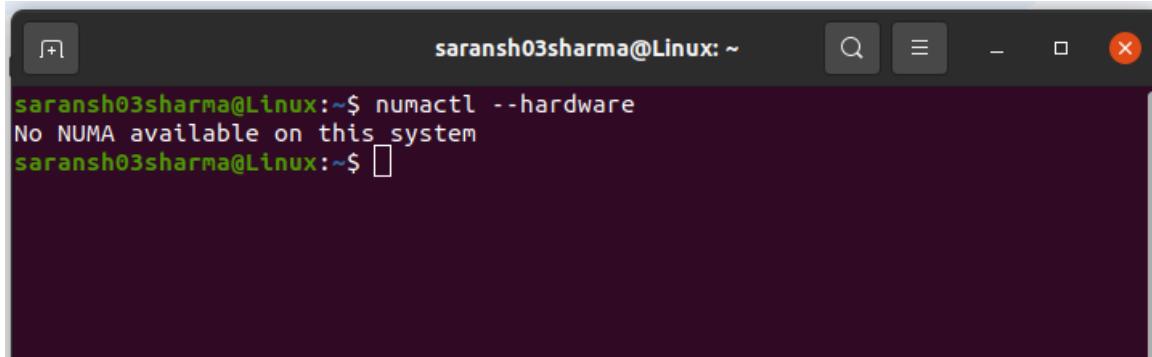
- In the .config file

The picture below shows that the CONFIG_NUMA field is not set in the .config file.

The screenshot shows a terminal window with the command "cat .config | grep -i CONFIG_NUMA" run by the user "saransh03sharma". The output shows that the "# CONFIG_NUMA is not set" line is present, indicating that the CONFIG_NUMA field is not currently configured in the .config file.

- Using numactl command

The picture below confirms the absence of NUMA support with the help of numactl –hardware command.

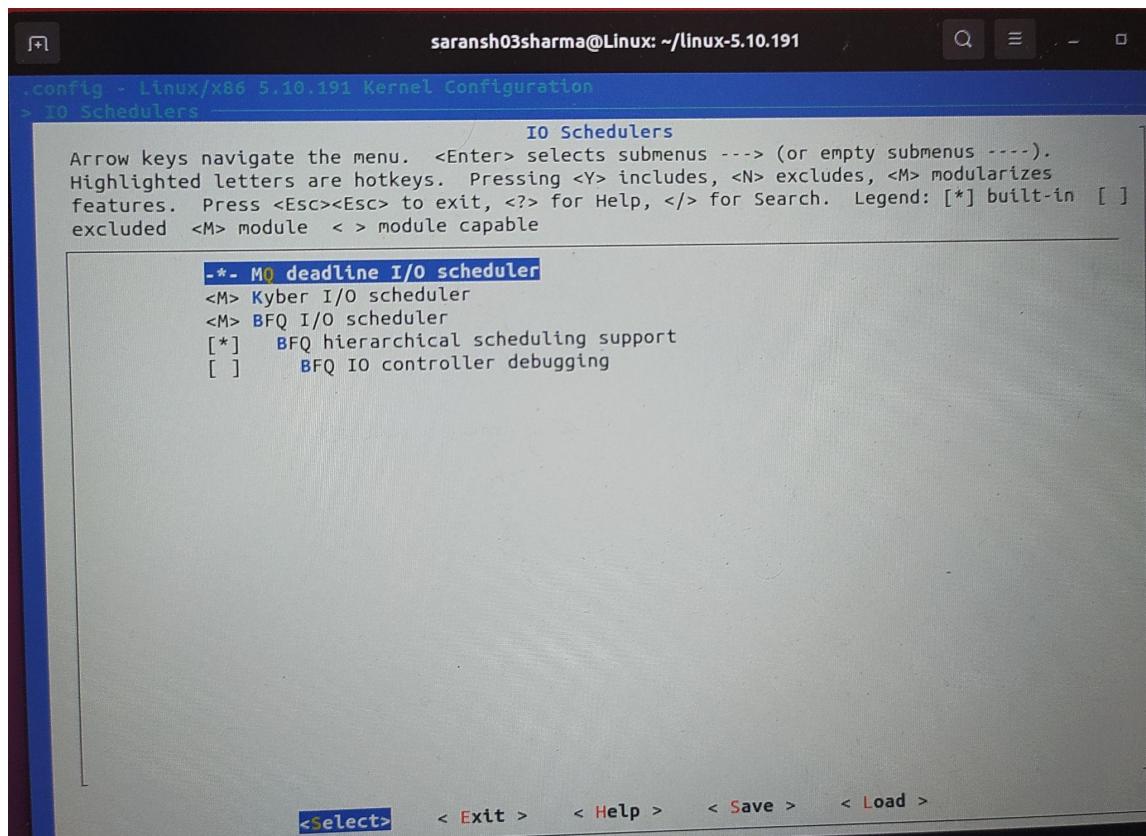


```
saransh03sharma@Linux:~$ numactl --hardware
No NUMA available on this system
saransh03sharma@Linux:~$
```

A screenshot of a terminal window titled "saransh03sharma@Linux: ~". The window shows the command "numactl --hardware" being run, which returns the message "No NUMA available on this system". The terminal has a dark background with light-colored text and standard window controls at the top.

Remove Kyber I/O Scheduler

Before Removal



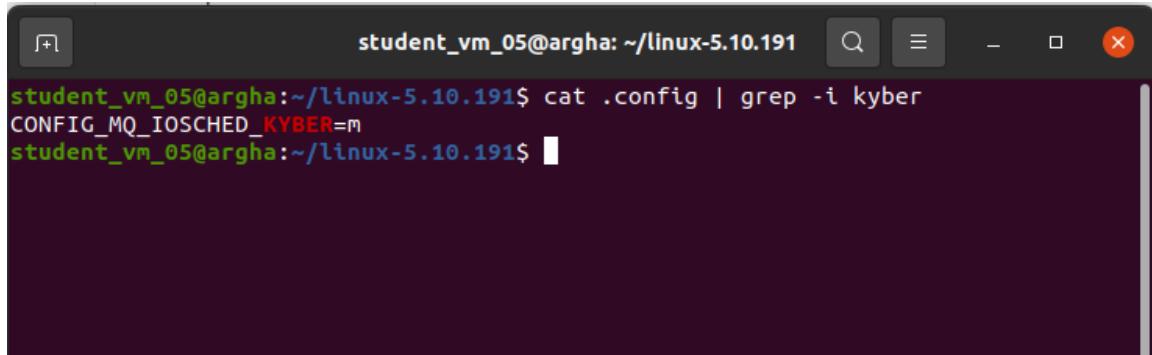
```
.config - Linux/x86 5.10.191 Kernel Configuration
> IO Schedulers
    IO Schedulers
    Arrow keys navigate the menu. <Enter> selects submenus --- (or empty submenus ----).
    Highlighted letters are hotkeys. Pressing <Y> includes, <N> excludes, <M> modularizes
    features. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] built-in [ ]
    excluded <M> module < > module capable
        -*- M0 deadline I/O scheduler
        <M> Kyber I/O scheduler
        <M> BFQ I/O scheduler
        [*]   BFQ hierarchical scheduling support
        [ ]     BFQ IO controller debugging

<Select> < Exit > < Help > < Save > < Load >
```

A screenshot of a terminal window titled "saransh03sharma@Linux: ~/linux-5.10.191". It shows the "IO Schedulers" section of the kernel configuration menu. The "Kyber I/O scheduler" option is highlighted with a blue border. The menu includes instructions for navigating and selecting options. At the bottom, there are buttons for "Select", "Exit", "Help", "Save", and "Load".

- In the .config file:

The picture below shows that the CONFIG_MQ_IOSCHED_KYBER field is set by default.



```
student_vm_05@argha:~/linux-5.10.191$ cat .config | grep -i kyber
CONFIG_MQ_IOSCHED_KYBER=m
student_vm_05@argha:~/linux-5.10.191$
```

- Verification

The picture below lists down all IO Schedulers available in the system with the help of ls /lib/modules/5.10.191/kernel/block command.



```
student_vm_05@argha:~/linux-5.10.191$ ls /lib/modules/5.10.191/kernel/block/
bfq.ko  kyber-iosched.ko
student_vm_05@argha:~/linux-5.10.191$
```

After Removal

IO Schedulers -> Kyber I/O scheduler

```
saransh03sharma@Linux: ~/linux-5.10.191
config - Linux/x86 5.10.191 Kernel Configuration
> IO Schedulers
          IO Schedulers
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty submenus ----).
Highlighted letters are hotkeys. Pressing <Y> includes, <N> excludes, <M> modularizes
features. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] built-in [ ]
excluded <M> module < > module capable
*- MQ deadline I/O scheduler
< > Kyber I/O scheduler
<M> BFQ I/O scheduler
[*]   BFQ hierarchical scheduling support
[ ]     BFQ IO controller debugging
<Select>  < Exit >  < Help >  < Save >  < Load >
```

- In .config file

The picture below shows that the CONFIG_MQ_IOSCHED_KYBER field is not set.

```
saransh03sharma@Linux: ~/linux-5.10.191$ cat .config | grep -i kyber
# CONFIG_MQ_IOSCHED_KYBER is not set
saransh03sharma@Linux:~/linux-5.10.191$ 
```

- Verification

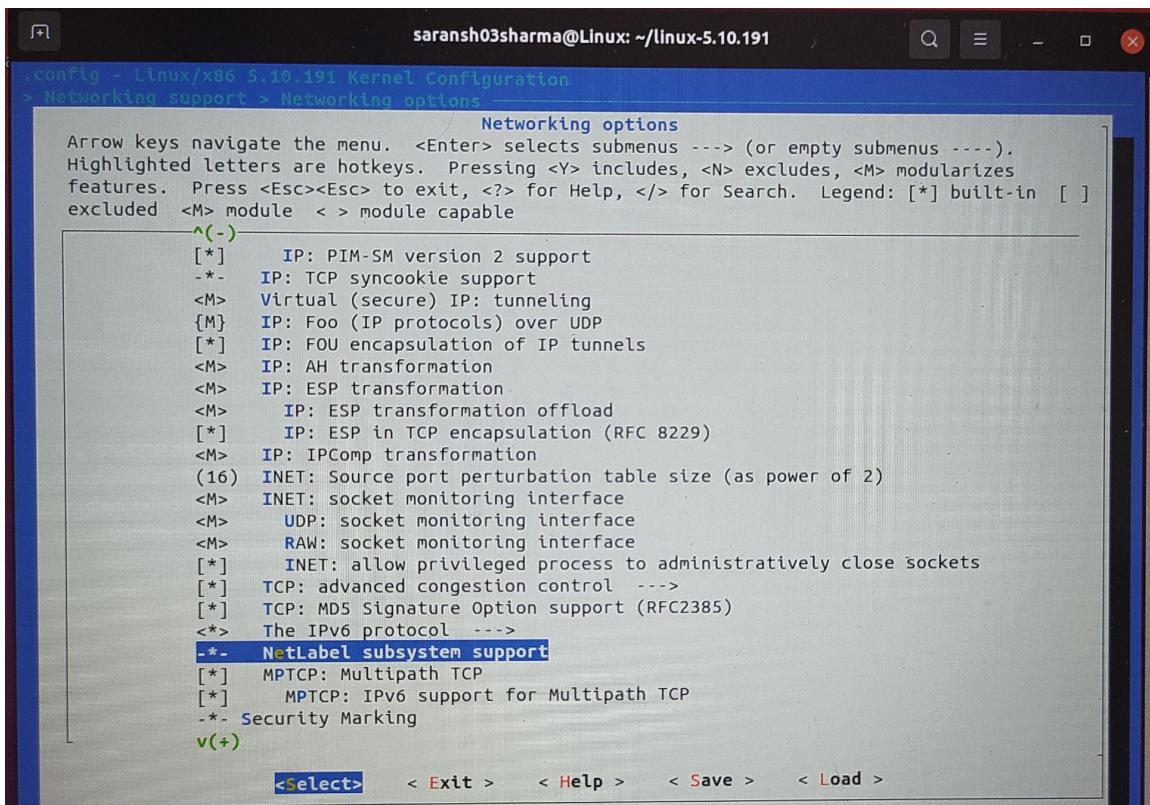
Upon listing all IO schedulers available by listing all files present under directory /lib/modules/5.10.191/kernel/block/, kyber-iosched.ko is absent.

```
saransh03sharma@Linux:~$ ls /lib/modules/5.10.191/kernel/block/
bfq.ko
saransh03sharma@Linux:~$ 
```

Include multipath TCP (MPTCP)

MPTCP is by default enabled in Linux kernel version 5.10.191. The same can be disabled by toggling Networking support → Networking options → MPTCP: Multipath support.

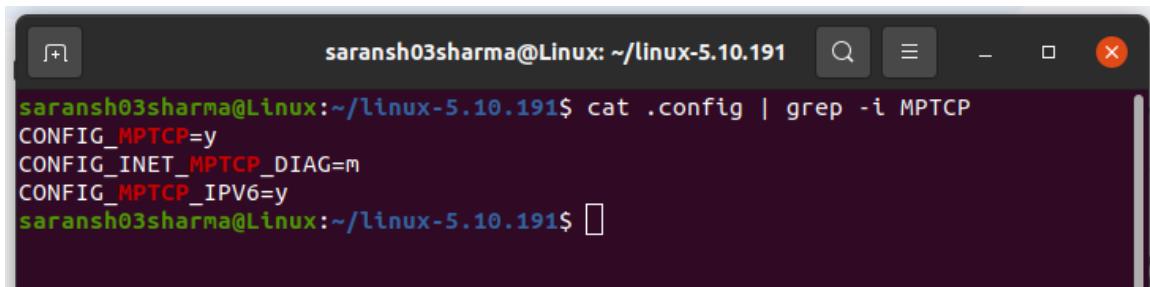
Enabled MPTCP:



The screenshot shows the 'Networking options' section of the kernel configuration menu. The 'NetLabel subsystem support' option is selected, indicated by a blue border around its line. Other options listed include PIM-SM, TCP syncookie support, Virtual IP tunneling, IPsec over UDP, FOU encapsulation, AH transformation, ESP transformation, ESP offload, ESP encapsulation, IPComp transformation, INET port perturbation, socket monitoring interfaces, RAW monitoring, INET privileged socket close, TCP advanced congestion control, TCP MDS support, and The IPv6 protocol. At the bottom, there are buttons for <Select>, <Exit>, <Help>, <Save>, and <Load>.

- In .config file

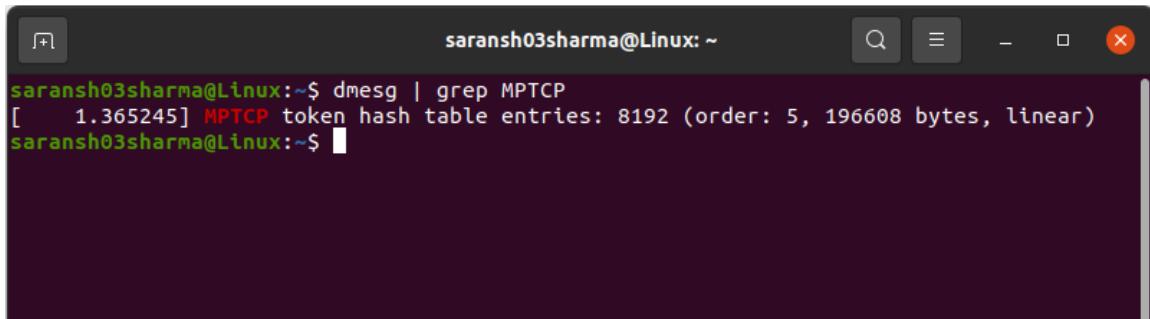
The below picture shows that the CONFIG_MPTCP field is set.



```
saransh03sharma@Linux:~/linux-5.10.191$ cat .config | grep -i MPTCP
CONFIG_MPTCP=y
CONFIG_INET_MPTCP_DIAG=m
CONFIG_MPTCP_IPV6=y
saransh03sharma@Linux:~/linux-5.10.191$ 
```

- Version Verification

To verify the version of MPTCP enabled in the system, the command dmesg | grep MPTCP is used.



A screenshot of a terminal window titled "saransh03sharma@Linux: ~". The window contains the following text:

```
saransh03sharma@Linux:~$ dmesg | grep MPTCP
[    1.365245] MPTCP token hash table entries: 8192 (order: 5, 196608 bytes, linear)
saransh03sharma@Linux:~$
```